(NASA-CR-161269) [AUTOMATED SEMICONDUCTOR VACUUM CHEMICAL VAPOR DEPOSITION FACILITY] Final Report (Tylan Corp., Torrance, Calif.) 8 p HC A02/MF A01 CSCL 07D

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NASA Contract NAS8-31617

Final Report

I. System Overview

The concept of this project was to develop a semiconductor vacuum chemical vapor deposition facility which was totally automated. Wafers would arrive at the facility on an air track, be automatically loaded into a furnace tube, processed, returned to the track, and sent on to the next operation. The entire process was to be controlled by a computer. Installation took place at NASA, MSFC, Huntsville, Alabama. NASA supplied one 2-stack furnace and the facility. Tylan supplied the remainder of the system and supervised installation and checkout at Huntsville. It was desired to demonstrate the following VCVD processes:

1. Polycrystalline silicon deposition.
2. Silicon nitride deposition.
3. Silicon dioxide deposition.
4. Doped silicon dioxide deposition and undoped deposition.

The major innovations desired in this procurement were the following:

1. A process controller specifically designed for semiconductor processing.
2. An automatic loading system to accept wafers from an air track, insert them into a quartz carrier, then place the carrier on a paddle for insertion into the furnace.
3. Automatic unloading of the wafers back on the air track.
4. Phosporous and boron-doped oxide depositions.

With the submittal of this report, all items of the Scope of Work have been completed with the exception of boron-doped silicon dioxide deposition.

This contract was a companion program of an automatic diffusion facility which Tylan also undertook to develop. The twin projects ran into many problems and mutual conflicts, particularly in respect to overlapping installation and start-up. In addition, there were facility problems at NASA which precluded making production-type runs. As a result of these various difficulties, there is no experience at the time of this writing on the productivity of the design.

I. System Overview (continued)

However, enough data has been gathered to suggest several improvements in future systems:

1. The Monitrol process controller is a first generation real-time controller for semiconductor processing. It has several shortcomings which have been identified--particularly in flexibility and capacity. A second generation system, called the Tycom 900, has been subsequently designed and put into production. It is proving to be superior to the Monitrol, overcoming all known problems in the MSFC installation. It should be used in the future.

2. A major problem encountered in the subject facility was the technique of rotating the quartz carrier 90° and laying it on the paddle. This was accomplished by a separate microprocessor control which worked from limit switch inputs. Although it worked within specified limits, the design was awkward, involved many parts and may require maintenance. This function can be better regulated by the new generation Tycom 900.

3. The air track occasionally allowed wafers to "hang up". The adjustment to keep this from happening is rather cirtical. It is believed that this problem can be overcome with a modest development program.

II. Operation

The overall VCVD facility consisted of the following:

1. One existing two-stack thermco diffusion furnace.

2. A special load station incorporating a wafer track and buffer tee.

3. An automatic wafer boat elevation system.

4. Two automatic boat insertion systems.

5. A computer-based process controller.

6. A source cabinet for the two gas blending systems.

7. Two vacuum systems.

8. Expendable materials--quartz, silicon carbide, etc..

Wafers arrive at the load station on a wafer track and are temporarily stored in a buffer-tee until required for loading into the furnace. When a furnace is ready, the wafers are sent along the track to a load station where a vertically-oriented quartz carrier holding 25 wafers is located. The wafers are loaded into the carrier which is then lifted by an automatic "claw" mechanism above the furnace to be used. Next, the silicon carbide paddle is retracted from the

II. Operation (continued)

furnace under the suspended carrier. At the proper time, the carrier is lowered onto the retracting paddle as the paddle retracts until it is lying horizontally on the paddle. The claw opens and retracts upward. The paddle goes into the furnace, carrying the wafer boat and its load of 25 wafers, then the process begins.

The control of all functions except the lowering of the wafer carrier on the paddle is accomplished by the Monitrol Process Controller. Carrier loading is directed by a separate microprocessor-based controller. Receipes for various processes are stored in the Monitrol. This unit contains a DEC PDP-8 minicomputer. It has complete manual backup of all functions as well as visual indication of operating state. It may be interfaced with an upstream computer for management data presentation.

III. Documentation

Tylan has submitted all the required documentation to operate the system. Attached is a complete drawing list for reference. Also attached is a photograph of the equipment.

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AUTO VACUUM CHEMICAL VAPOR DEPOSITION SYSTEM

DPS-1013

3881-010	INSTALLATION DWG.	E	2-shts	8 -23-76
3881-022	WIRING SCHEMATIC, E.E. BOX	E		5 -19-77
3881-023	WIRING SCHEMATIC, HOR. BOAT PUSHER	C		10-18-76
3881-024	WIRING SCHEMATIC, POSITION SW. HOR.	C		10-18-76
3881-025	SCHEMATIC, BOAT PUSHER, SPEED CONTROL	D		10-18-76
3881-026	WIRING SCHEMATIC, VERTICAL DRIVE	D		10-18-76
3881-027	WIRING SCH., POLY S1/SILICON NITRIDE & DOPED OXIDE	E		5 - 6-77
3881-028	WIRING SCH., MONITROL MANUAL CONTROL PANEL	D		5 - 6-77
3881-029	WIRING SCHEMATIC, VACUUM MODULE	D		5 -19-77
3881-030	SCHEMATIC, INPUT BOARD	E	3-shts	5 -19-77
3881-031	SCHEMATIC, OUTPUT BOARD	E	3-shts	5 -19-77
3881-101	LOAD STATION	E		8 -24-76
3881-102	GUIDE, VERTICAL, WAFER BOAT	D		8 -13-76
3881-103	GUIDE BLOCK, FRONT	B		8 -13-76
3881-104	PAD, VERTICAL GUIDE	B		8 -13-76
3881-105	PLATE, MOUNTING, BEARING HOUSING	C		8 -13-76
3881-106	ARM, EXTENDING	B		8 -13-76
3881-108	COVER, VERTICAL DRIVE	D		9 -13-76
3881-109	ACCESS DOOR	C		8 -25-76
3881-113	ADAPTER, SEALING PLATE	C		8 -13-76
3881-114	BRACKET, INTERFACE	C		9 -23-76
3881-117	BASE PLATE, AIR TRACK	D		8 -13-76
3881-118	CLIP, FLANGE SUPPORT	C		9 - 7-76
3881-119	SUPPORT, VACUUM LINE	C		9 -10-76
3881-121	BASE, VACUUM MODULE	D		9 - 7-76
3881-122	TEE, MODIFIED	C		9 - 1-76
3881-123	ADAPTER, VACUUM EXHAUST	C		9 - 7-76
3881-124	ADAPTER, PUMP TO GATE VALVE	C		9 - 1-76
3881-125	END PLATE, VACUUM MODULE	D		9 -23-76
3881-126	SUPPORT, END PLATE	C		9 -23-76
3881-127	VACUUM LINE, PUMP END	C		9 - 7-76
3881-128	VACUUM LINE, PROCESS TUBE END	C		9 - 7-76
3881-129	PANEL, MONITROL CABINET	C		9 -10-76
3881-130	PANEL, FURNACE	C		9 -23-76
3881-131	GUIDE, VERTICAL DRIVE	C		9 - 7-76
3881-132	COVER, HORIZONTAL DRIVE	C		9 -13-76
3881-133	PANEL, GAS PANEL COVER	D		9 -23-76
3881-134	TOP, GAS PANEL COVER	C		9 -23-76
3881-135	BOTTOM, GAS PANEL COVER	C		9 -23-76
3881-136	SIDE, GAS PANEL COVER	C		9 -23-76
3881-137	END FITTING, VERTICAL DRIVE CABLE	C		10- 7-76
3881-138	ADAPTER HOSE, VACUUM FLANGE	C		10-20-76

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SEQUENCE OF OPERATION OF THE AUTOMATIC

LOADING STATION

A. LOADING SEQUENCE

1. Push BT RQST (X).
2. Horizontal B.P. (X) starts to pull and hits the out L.S. (S), B.P. (X) stops.
3. Claw opens, the vertical B.P. starts to come down.
4. It hits the vertical L.S. (X). The position L.S. on the claw is activated, the vertical B.P. stops.
5. Claw closes and the vertical B.P. starts going up with the boat.
6. Position L.S. is deactivated and horizontal B.P. (X) starts to push until the position L.S. is activated again, then it stops. The vertical B.P. is moving up all the time and the operation repeats until the horizontal B.P. hits the center L.S. (X).
7. The vertical B.P. goes up in a faster pace and the horizontal B.P. (X) continues to push in.
8. The vertical B.P. hits the uppper L.S. and stops.
9. The horizontal B.P. (X) hits the in L.S. (X) and stops.
10. The vertical B.P. starts coming down.
11. It hits the B.T. limit switch and slows down.
12. It places the boat in the B.T. and the boat handle activates the position L.S. on the claw.
13. The claw opens and the carriage starts to go down with the boat.
14. The carriage stops at the bottom of the B.T.
15. The other B.T. starts to send wafers.
16. The wafer is caught in the boat and the carriage indexes up one slot.
17. The operation repeats until all wafers are received.

18. The carriage moves to the upmost position.

19. The claw closes and picks up the boat.

20. The vertical B.P. starts to go up until it hits the upper L.S. and stops.

21. The horizontal B.P. (X) starts to pull out.

22. It hits the middle L.S. (X) and stops.

23. The vertical B.P. starts to come down slow.

24. It places the boat onto the paddle and stops when the position L.S. on the claw is activated.

25. The horizontal B.P. (X) starts to pull out very slowly.

26. When the position L.S. deactivates, the vertical B.P. starts to drop again.

27. Operation repeats until either:

    a) The horizontal B.P. (X) hits the out L.S. (X) and stops. The vertical B.P. continues to come down until it hits either the position L.S. or the vertical L.S. (X) and stops.

    b) The vertical B.P. hits the vertical L.S. (X) and stops The horizontal B.P. (X) stops at the same time.

28. Claw opens up and the vertical B.P. goes up to the top limit position.

29. The horizontal B.P. (X) starts to push in with the boat until it hits the in L.S. (X).

B. UNLOADING SEQUENCE

1. Push PCS END (X).

2. Same as A-2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12 and 13.

3. When the air sensor senses the wafer, the carriage stops and sends out a wafer.

4. The operation repeats until all the wafers are sent.

5. Same as A-14.

6. Same as A-18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28 and 29.

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(continued)

3881-139	COVER, VACUUM FLANGE	C	11- 4-76
3881-140	MOUNTING BLOCK, VACUUM FLANGE COVER	B	10-29-76
3881-141	CABLE ASSEMBLY, BUFFER T	C	10-26-76
3881-142	FREQUENCY DIVIDER BOARD	B	11- 1-76
3881-143	FRONT PANEL, ELECTRICAL BOX	C	11- 1-76
3881-144	BRACKET, LAMP	C	11-10-76
3881-145	ADAPTER, VACUUM PUMP PURGE	B	11-17-76
3881-146	EXHAUST ADAPTER, GAS PANEL	B	3 -14-77
3881-151	MONITROL CABINET ASSEMBLY	E	10-19-76
3881-152	PANEL, CONNECTOR	C	10-19-76
3881-201	PLUMBING SCHEMATIC, DPS-1013	E	9 - 1-76